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Infrastructure in developing countries: An overview of some economic issues

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ABSTRACT

This paper surveys the main issues and controversies in the economic literature on infrastructure in developing countries. Section I reviews the evidence on the role of infrastructure in promoting economic growth. It is argued that, although infrastructure may be more important for growth than other types of capital, the exact size and form of its effect is less clear than is often assumed. Section II looks at the issue of infrastructure "needs", estimates of which are pervasive in both the academic and policy literature. It is argued that the preoccupation with such estimates is largely misplaced. More crucial is to develop systems of infrastructure enabling competition through an appropriate market structure. Therefore, section III reviews the economic fundamentals of infrastructure and the available market structure options and section IV considers means to attract and enable private investment. This is an important means of encouraging competition which has been amongst the top priorities of multilateral banks such as the World Bank or the European Investment Bank. Finally, section V reviews some of the literature debating whether public investment is fundamentally more cost-effective than private investment in infrastructure. There has been renewed interest in this question since the onset of the 2008 global financial crisis, with many countries now seriously questioning the rationale of replacing public with private finance.

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JEL classification: L9, L16, O16, O2

INTRODUCTION

In developing countries, more than a quarter of households have no access to electricity—with 70 percent of the African population unconnected; some 884 million people have no access to an improved water source and 2.6 billion people lack access to improved sanitation. Only 70 percent of the population in developing countries (and 33 percent in Africa) have access to an all-weather road. Enterprise surveys reveal that delays of 30 days or more are the norm for connections to electricity, telephone, and water in developing countries. The electricity-generating capacity in low-income countries is about 100,000kw/person compared to about 2,300,000 kw/person in rich countries (Fay, Toman, Benitez, Csordas 2011). Moreover, complaints about lack of water or electricity service, low quality service or infrequent service are commonplace. Prestige projects benefitting the rich and "white elephants" abound in developing countries (and in developed countries, though less frequently). In many developing countries, infrastructure services are often of poor quality and investments in infrastructure are needed to improve the living standards of the population and boost enterprise productivity. Table 1 shows that the stock of infrastructure is on average between 8 to 20 times larger in richer countries than in developing countries.

Table 1. Stock of Infrastructure in Developed and Developing Countries

	Electricity production per capita (kWh)	Electricity consumption per capita (kWh)	Average telephone mainlines per 100 persons	Road density (km/sq. km of land)	Access to improved water source (% population)
	2008	2008	2009	2008	2008
Developing countries	1,647	1,510	13	0.22	84
East Asia	2,091	1,964	20	0.36	88
Europe & Central Asia	4,652	4,082	26	0.08	95
Latin America	2,257	1,894	18	0.18	93
Middle East & N.Africa	1,771	1,514	16	0.12	87
South Asia	636	508	3	1.29	87
Sub-Saharan Africa	522	536	1	-	60
Developed Countries	9,953	9,478	45	0.43	99

Source: World Bank *World Development Indicators*. Original sources are: International Energy Agency, International Telecommunication Union, International Road Federation, World Health Organisation and United Nations Children's Fund. Road density data are for the latest year available.

Progress in improving infrastructure in developing countries has been slow. Many poor countries cannot mobilize resources for that purpose. Even when these resources are mobilized, they are often spent in a very inefficient way. Slow progress reflects a combination of insufficient and inefficient spending both in capital expenditures and in operations and maintenance. Many governments, faced with competing priorities or difficult fiscal situations, simply do not or cannot allocate the resources needed to reach desirable levels of access or quality. In addition, infrastructure services often are public goods or natural monopolies, or both. As such they are either run or regulated by public entities and thus suffer from some common inefficiencies of public services.

During the 1990s about one-quarter of infrastructure investment in developing countries involved private participation. Since the 1990s, private participation in infrastructure (PPI) has grown at an average rate of 13 percent a year.[1] However PPI has been very concentrated geographically, with the top six countries accounting for about half of PPI in recent years (increasing to 60 percent in 2008). Historically PPI represented a fairly even share of GDP for all regions except the Middle East and North Africa and East Asia. But that changed in recent years, with Europe and Central Asia, South Asia, and Sub-Saharan Africa seeing PPI gain in importance and reaching some 2 percent of GDP. In contrast, PPI became relatively less important for East Asia and Latin America. [2] PPI is viewed as a way to raise the necessary funds. [3] It is unclear what share of overall investments PPI investment represents, although various authors have estimated it to be 20–25 percent. In Africa, PPI has contributed to 10–15 percent of needs in recent years, but much of it is concentrated in South Africa (and to a lesser extent Kenya).

More recently, PPI has amounted to a striking 4 percent of low-income countries' GDP—much higher than in richer developing countries, where it averaged 1.2–1.3 percent of GDP. The concentration of PPI flows in upper-middle-income countries (55 percent of PPI flows since 1990) declined in recent years as low income countries nearly doubled their share from 7 to 12 percent. More generally the concentration of PPI is roughly in line with global GDP concentration. However, three-quarters of low-income country PPI investment has been in telecom, as opposed to a bit less than half for middle-income countries.

There has been another major historical change recently. Large-scale operators from high income countries increasingly are being replaced by developing-country investors who have emerged as a major source of investment finance for infrastructure projects with private participation. During 1998–2006 developing-country investors contributed more than half the private investment in concessions (55 percent), half in greenfield projects (50 percent), and a smaller share in divestitures (29 percent). The large majority of the funding came from

[1] The data is from http://ppi.worldbank.org and this paragraph draws on Fay, Toman, Benitez and Csordas (2011).

[2] Sectorally PPI has been concentrated in telecommunications, which has accounted for about half of all investment commitment of the past 20 years. Energy is a distant second (30 percent of total), followed by transport (17 percent), while water and sanitation never represented a large share.

[3] The World Bank's Private Participation in Infrastructure (PPI) database is often relied on to measure private investment levels across countries and sectors—but this is misleading. This database actually measures the value of projects owned or managed by private operators – but the capital can be provided by either public or private parties. Note that private investment in infrastructure can be direct (such as building and operating a project) or indirect (such as purchasing a government infrastructure bond). In general it is reasonable to assume that private capital and private ownership (or management) are one and the same thing since PPPs typically consist of both private finance and private ownership (until assets are returned after contract expiration). But there is a distinction between private capital and private participation. This is because it may be optimal for the government to choose one but not the other; it may attempt to combine the efficiency gains from private management with the cost advantages of sovereign borrowing for example.

local companies investing in projects in their own country ("developing local" investors); almost all the rest came from investors from nearby countries (Schur et al. 2008).

This paper provides an overview of the main issues and controversies in the current literature on infrastructure in developing countries. We first look at the evidence on infrastructure's role in promoting growth, which has attracted a huge volume of work. We argue that although infrastructure may be more important for growth than other types of capital, the exact size and form of its effect is less clear than is often assumed. We then move on to look at the issue of infrastructure "needs", estimates of which are pervasive in both the academic and policy literature. We argue that the preoccupation with such estimates is largely misplaced. More crucial, we argue, is developing systems of infrastructure that enable competition through an appropriate market structure. We therefore review the economic fundamentals of infrastructure and the available market structure options before devoting a section to attracting private investment. Not only is this an important means of encouraging competition, but it has been amongst the top priorities of multilaterals such as the World Bank. Finally, we review the body of literature which debates whether public investment in infrastructure is fundamentally more cost-effective than private investment. There has been renewed interest in this question since the onset of the 2008 global financial crisis, with many countries now seriously questioning the rationale of replacing public with private finance.

HOW ESSENTIAL IS INFRASTRUCTURE FOR ECONOMIC GROWTH?

We begin by reviewing empirical studies of the long run impact of infrastructure on economic productivity and growth. Quantitative assessments of the effects of public infrastructure capital on total factor productivity (TFP) began with the seminal work of Aschauer (1989) who, using annual time-series data for the USA, calculated that, holding constant private inputs, private GDP would increase permanently by more than one to one for every additional unit of non-defense public capital—in other words, that the annual marginal product of public capital is in excess of 100 percent. Aschauer's results were based on a static production function estimated with yearly US data in levels. Subsequent research estimating production functions using pooled US state data in levels, disaggregating public capital into its main components, or using industry data also found similar effects, particularly for roads and highway capital. Time series estimates in levels might simply capture common trends—and pooled state data in levels might simply capture underlying persistent state characteristics – richer states invest more in public capital. In fact, when the production function is estimated with aggregate US data in differences, or with state data with fixed effects, zero or even negative marginal products of public capital become typical (Perotti 2007).

In this literature, infrastructure is variously measured in terms of physical stocks (e.g., km of roads or number of telephone lines) or pecuniary stocks constructed by accumulating spending flows. The underlying assumption is that the flow of productive infrastructure

services is directly related to the size of the stock of infrastructure assets, analogously to what is routinely assumed about the services of human and physical capital (Serven 2010). A number of empirical studies using various approaches also find that the output contribution of infrastructure exceeds that of conventional capital, which suggests the presence of externalities associated with infrastructure services. [4]

This literature focuses on quantifying the impact of infrastructure on aggregate output without generally specifying the channels through which the impact occurs. A majority of studies report a significant positive effect of infrastructure on output, productivity, or their growth rate. This is mostly the case with studies using physical measures of infrastructure stocks; in contrast, results are less conclusive among studies using pecuniary measures such as public investment flows or their accumulation into public capital. There is a good reason for this, namely the lack of a close correspondence between public capital expenditure and the accumulation of public infrastructure assets or the provision of infrastructure services, owing to inefficiencies in public procurement and outright corruption – issues that are likely more important in developing economies than in more advanced ones (Serven 2010).

The recent literature tends to find smaller (and more plausible) effects than those reported in Aschauer and other earlier studies (Romp and de Haan 2007). The mid-point estimate from recent studies of the elasticity of GDP with respect to infrastructure capital with a production function approach lies around 0.15 for developed countries (Bom and Ligthart 2009). This means that a doubling of infrastructure capital raises GDP by roughly 10 percent. Estimates from recent studies using broader country samples (e.g. Easterly and Serven 2003) are not very different. However, this captures only the direct effect of infrastructure on output, given the use of other productive inputs. There may be additional indirect effects accruing through changes in the usage of the other inputs due to complementarities with infrastructure.

[4] Consistent and comparable data on infrastructure spending, stocks, and services in developing countries do not exist. Data on private investment in infrastructure are fragmentary and there is no comprehensive source. The most frequently used sources are Dealogic, a private platform used by investors, and the World Bank's Private Participation in Infrastructure database. The main data source for public investment in infrastructure is the IMF Government Financial Statistics but it focuses primarily on central government accounts and provides a very incomplete coverage of infrastructure expenditure, much of which is undertaken by subnational and parastatal entities. For instance, infrastructure expenditure data between 2000 and 2005 is reported only for Uganda out of the 42 Sub-Saharan African countries and indicates an implausibly low spending level of 0.2 percent of GDP in 2001. Delivery of infrastructure services relies heavily on public or parastatal agencies outside the purview of the central government. A significant share of public expenditure in infrastructure is channeled through nonfinancial public enterprises, local governments, and off-budget vehicles such as special funds. Off-budget vehicles play an increasingly large role in mobilizing and protecting the infrastructure financing of several sectors, including roads (and rural infrastructure in general), even when part of their resources continue to be come via budget transfers. Cecilia Briceño-Garmendia and Afua Sarkodie (2011) have developed a methodology and are producing a standardized database of public expenditure levels and performance in infrastructure comparable across countries. Aiming to be as comprehensive as possible, it covers central and subnational government expenditures, nonbudgetary vehicles (such as road funds and rural infrastructure funds), state-owned enterprises (SOEs), and public-private partnerships (PPPs) in which the asset ownership remains with the government.

The findings from reduced-form growth regressions are somewhat harder to summarize, because different studies condition on very different sets of non-infrastructure variables. Nevertheless, estimates from recent studies based on panel data combining industrial and developing countries suggest that a 1-percent increase in physical infrastructure stocks, given other variables, temporarily raises GDP growth by as much as 1-2 percentage points, although the growth acceleration gradually tapers off as the economy approaches its long-run per capita income.

Channels

Infrastructure affects productivity and aggregate output through direct and indirect channels. First, infrastructure increases TFP directly because infrastructure services enter production as an additional input and have a direct impact on the productivity of enterprises (Serven 2010; Dethier, Hirn and Straub 2010). Second, infrastructure raises TFP by reducing transaction and other costs thus allowing a more efficient use of conventional productive inputs. In addition, it can affect investment adjustment costs, the durability of private capital and both demand for and supply of health and education services (Agénor and Moreno-Dodson 2006). Absent or unreliable transport, electricity or telecom services imply additional costs for firms or prevent them from adopting new technologies. Better transportation increases the effective size of labor markets. Various micro studies suggest an impact on human capital of access to water and sanitation (via health) and electricity and transport that facilitate access to schools and the ability to study (Brenneman 2002). The relative infrastructure endowments will affect a region's comparative advantage, hence its development (Estache and Fay 1997).

The empirical literature dealing with the channels through which infrastructure affects productivity and/or output is reviewed in Straub (2008), Straub, Vellutini and Warlters (2008), Romp and de Haan (2007), Briceno et al (2004) and Gramlich (1994). Microeconomic studies conclude to a high impact of infrastructure on growth while others find negative or zero returns. The majority of studies, however, conclude that infrastructure matters for economic growth and production costs, but its impact is higher at lower levels of income. Romp and de Haan (2005), for instance, note that of 32 of 39 OECD country studies found a positive effect of infrastructure on some combination of output, efficiency, productivity, private investment and employment. Of the remaining seven, three had inconclusive results and four found a negligible or negative impact of infrastructure. Romp and de Haan (2005) also review 12 developing country studies. Of these, nine find a significant positive impact. The three that find no impact rely on public spending data (which are notoriously imprecise, especially for cross-country analysis). A majority of studies conclude that infrastructure generally has a significant impact on growth, particularly in developing countries. Calderon and Serven (2004) report that 16 out of 17 studies of developing countries find a positive impact as do 21 of 29 studies of high income countries. Briceño et al (2004) review more than 100 papers and reach similar conclusions. Nevertheless, there is a lot of variance in the returns and elasticities reported by the various studies—which should not be a surprise since

one cannot expect the effects of infrastructure on productivity to be positive and constant, over time or across countries.

Network Effects

Infrastructure services are mostly provided through networks, a fact that implies a nonlinear relation with output. Telecom exhibits pure network externalities whereby returns to users increase with the number of users. The same can probably be said of water and sanitation networks where the public health value of safe water and sanitation systems are likely to increase the more individuals are served, in a kind of herd-immunity effect. But roads, rail, and electricity are also networked services so that the impact of new investments on growth, output or firm costs will depend on the overall state and extent of the network (Romp and de Haan 2007). In other words, the marginal and average productivity of investments are likely to differ significantly and the hypothesis of a constant or linear elasticity of output with respect to infrastructure is clearly incorrect.

A few authors have explicitly modeled the non-linearity of infrastructure's impact on output, growth, or production costs. Thus, Röller and Waverman (2001) find that the impact of telecommunication infrastructure on output is substantially higher in countries where penetration approaches universal coverage. In the case of roads, Fernald (1999) looking at the US found that returns to investments were very high up to the point when the basic interstate network was completed. He argues that the completion of that network provided a one-time boost in US productivity.

Threshold effects in infrastructure can be modeled in a variety of ways – through a measure of completeness of coverage as discussed above, or more simply through some measure of income as in Canning and Bennathan (2000). Hurlin (2006) develops a threshold model whereby the level of available infrastructure is the threshold variable but the number and value of the thresholds are endogenously determined. Applying this to the multi-country panel data set of Canning and Bennathan (2000), he finds strong evidence of non-linearity and concludes that the highest marginal productivity of investments is found when a network is sufficiently developed but not completely achieved. The effect of infrastructure may well also vary over time as other changes in the economy influence firms' abilities to take advantage of it. Thus Albala-Bertrand and Mamatzakis (2007) find that infrastructure's productive impact became much more pronounced after 1973 in Chile when the economy liberalized.

If network externalities (yielding non-linear effects) are not properly captured, the payoffs to infrastructure investments will be under- or over-estimated. Variables likely to affect this are the stage of development of the network and a number of institutional variables such as the degree of liberalization of the markets and of competition across sub-sectors that will affect the quality of the overall network.

Endogeneity

Does infrastructure drive economic growth or vice versa? Causality between income and infrastructure may run both ways. The fact that demand for electricity, telephone and cars increases with disposable income is well documented in the literature (Chen, Kuo and Chen 2007, Ingram and Liu 1999, Röller and Waverman 2001). The extent of reverse causation varies across types and measures of infrastructure. For example, road networks that are long lived and slow to change are perhaps less likely to respond to changes in income (particularly in countries that already have a large network and where changes to cope with congestion (more lanes, better traffic management, ring roads etc) will not substantially affect aggregate measures (such as km of roads per capita)). Not so with telephones or electricity generating capacity (which responds to energy demand whose income elasticity has been around 0.5 since 1990 according to the International Energy Agency). Countries tend to increase their investments in environmental amenities as they become wealthier. Even studies that rely on constructed TFP estimates (whereby TFP growth as the dependent variable is by construction orthogonal to capital) may well still suffer from reverse causation if growth then influences decisions to invest in infrastructure (Straub and Vellutini 2006).

It may also be the case that a common factor causes both higher income and higher infrastructure endowment. Most of the criticism of Aschauer's 1989 work—with its findings of implausibly high rates of return—centers on a failure to appropriately correct for the possibility that an omitted variable drives the results. Later papers correct for this by introducing country (or region) fixed-effects and find much lower rates of return (see Gramlich 1994). However, the fixed effects approach precludes looking at the impact of other slow moving variables which is why a number of authors prefer not to use it.

An alternative approach is to try to isolate the impact of changes in infrastructure on long term growth, typically by using first-differences. But this approach generates its own set of problems. First-differences ignore the long-term relationship that exists in the data if infrastructure and growth are co-integrated (which Canning and Pedroni 2008 find to be the case). A number of studies also devise estimation methods that make clear which way the causality runs (see the discussion in Romp and de Haan 2007). Fernald (1999) uses industry level productivity growth in the US to measure the impact of road investments, and Canning and Pedroni (2008) find robust evidence that causality runs both ways but that in the vast majority of cases infrastructure does induce long run growth effects although they do find a great deal of variation across individual countries. Finally, a number of authors rely on simultaneous equations systems that look at the determinants of supply of (and/or demand for) infrastructure as well as its impact on output or growth. Röller and Waverman (2001) and Esfahani and Ramirez (2003) are good examples of careful attempts in this direction. The latter is also one of the few that uses first differences, and models both income per capita growth and infrastructure accumulation.

Measurement Issues

Measuring the effects of public infrastructure investment on the growth of the economy is fraught with difficulties. A limitation of the production function approach is the joint endogeneity of private inputs and outputs. Besides using instruments of dubious validity in estimating production functions, a frequent response has been to use a cost function approach, which takes as given private input prices instead of quantities. This is hardly a solution, though: at the typical level of aggregation of these studies (industries or US states) private input prices are also likely to be jointly determined with input and output quantities. Applications of these approaches to individual developing countries are rare. For instance, the paper by Albala-Bertrand and Mamatzakis (2007) cited earlier estimates a cost function using disaggregated data on different types of public capital in Chile. It is fair to say that they are not common.

More common for developing countries have been cross-section or panel data estimates of production functions, regressing GDP on private capital and public capital, often disaggregated by type. Good examples are Canning and Bennathan (2000) and Calderón and Servén (2003). Both are based on a careful reconstruction of different types of public capital stocks in a number of countries at all income levels. Calderon, Moral-Benito and Serven (2011) examine the impact of the level (not the change) of infrastructure on growth, drawing from an infrastructure stocks dataset covering 88 countries for 1960-2000. [5] They conclude that increases in (the quantity and quality of) infrastructure, while being worthwhile, are extremely costly and take decades to implement. It may well be that the fiscal distortions associated with such an effort, and the trade-offs it would entail with other needed investments would substantially reduce the net growth effect.

Cross section or panel production function regressions are similar in nature to growth regressions with public infrastructure on the right hand side, pioneered by Easterly and Rebelo (1993), who found large positive effects of public infrastructure on growth, and by Devarajan, Swaroop and Zou (1996), who instead found weaker effects.

Whether cost functions or production functions, or standard growth regressions, these all suffer from the same well-known problems of growth regressions: parameter heterogeneity,

[5] Calderon, Moral-Benito and Serven (2011) estimate a long-run aggregate production function relating GDP to human capital, physical capital, and a synthetic measure of infrastructure given by the first principal component of infrastructure endowments in the transport, power and telecommunication sectors. They use a panel time-series approach and deal with the endogeneity of the explanatory variables with GMM techniques. The estimation of parameters is performed using the pooled mean group (PMG) estimator, which allows for unrestricted short-run parameter heterogeneity across countries while imposing the (testable) restriction of long-run parameter homogeneity. The estimated long-run elasticity of output with respect to the synthetic infrastructure index ranges between 0.07 and 0.10, and the marginal productivity of infrastructure exceeds that of other physical capital. The estimates are highly significant, both statistically and economically, and robust to the use of alternative dynamic specifications and infrastructure measures. Homogeneity tests reveal little evidence of long-run parameter heterogeneity across countries, whether heterogeneity is unconditional, or conditional on the level of development, population size, or infrastructure endowments.

sensitivity to outliers, and model uncertainty. The most important problem—shared by simple time-series estimates of production and cost functions for individual countries—is the endogeneity of public investment (Calderón and Servén 2004): in country-periods where growth is "unusually" high given the values of the right hand side variables, it is plausible to think that the policymakers will have the resources to spend more on public infrastructure projects (a positive correlation between residual and regressor) and in some country-periods with unusually low rates of growth, it is plausible to think that policymakers might spend more on infrastructure in an attempt to raise growth (a negative correlation). This problem can be solved if one can find plausible instruments: but such instruments are exceedingly rare in the context of growth theory. For instance, typical instruments for the stock of public infrastructure capital are demographic variables like population density and urbanization. Yet, it is difficult to argue that, over long periods of time, they are exogenous to growth.

Political Economy

Private entrepreneurs arbitrage between different types of investment in order to maximize overall return when it comes to non-infrastructure investment. But, as we will see below, this is generally not the case with infrastructure which is generally not faced with a real market test. Therefore we cannot assume that the right capital is built at the right time or place and we should expect differences in rates of return across different projects. In addition, public infrastructure spending may be affected by public sector spending inefficiency. As a result, while financial estimates of investment in private capital may be a good proxy of the increases in private physical capital and may serve as the basis for constructing a stock figure through a perpetual inventory method, this is much less likely with infrastructure.

Therefore we need to better understand how decisions to invest in infrastructure are made since they affect the rate of return and efficiency of investments. It may also help identify how to improve expenditure efficiency. Politically motivated projects are likely to exhibit low (or lower) rates of return since their objective is to yield votes (or political favors) rather than to maximize growth. Public infrastructure investments may also have legitimate non-economic goals such as the physical or social integration of a country, or public health or safety concerns. Examples of papers dealing with the political economy of infrastructure investment decisions include Benitez, Estache and Soreide (2010), Robinson and Torvik (2005), Alesina, Baqir and Easterly (1999) and Rauch (1995). The extent and impact of pork-barrel politics is likely to vary. De la Fuente and Vives (1995) found little trace of political influence in Spanish infrastructure decisions, while Cadot et al (2006) find it in France. There may be lags in infrastructure's impact on growth. Most infrastructure is long-lived, and it could be that its full impact is slow in coming as firms adjust slowly to the new opportunities offered. Duggal et al (2007) find the productivity impact of increased IT infrastructure and associated private capital to have an approximate 4 to 5 year lag in the US.

MOVING BEYOND "INFRASTRUCTURE NEEDS"

Extrapolating Demand from Previous Trends

In response to the clear infrastructure deficiencies of most developing countries, and a broad consensus in the literature that infrastructure is important for growth, a number of authors have attempted to provide estimates of infrastructure "needs". A useful starting point of course is to determine the level of demand. Demand for infrastructure increases with income. For instance we know from empirical studies that electricity use, telephone use and automobiles increase with disposable income. Countries also tend to increase their investments in environmental amenities as they become wealthier. But when investment is planned, how is the demand for infrastructure determined? It is often done with reference to some norm (which could be be derived from cross-country studies on past levels of investment, or from a legal requirement for service quality such as continuous service 24 hours a day). Some economists believe that development requires that a certain percentage of GDP be invested in infrastructure. However, whether it actually makes sense to spend a fixed amount of GDP is debatable (Klein 2011). Consider a norm that says a country should invest 7 per cent of GDP in infrastructure annually. The idea behind such a norm is the notion that the economic performance of a country requires a fixed proportional amount of infrastructure—but many empirical growth studies have shown that this notion is erroneous. Investment in infrastructure based on predicted GDP growth (i.e., using the past as a predictor for the future) would yield the data shown in table 2.

Table 2. Infrastructure Expenditure Needs (in percent of GDP)

Country Type	*Investment*	*Maintenance*	*Total*
Low income	7.0	5.5	12.5
Lower middle income	4.9	3.3	8.2
Upper middle income	1.3	1.0	2.3
Total Developing	2.7	4.1	6.6

Source: Yepes (2008)
Note: These percentages represent expenditures needed to respond to increased demand for infrastructure services associated with projected income increases. Infrastructure refers to water, sanitation, transport and telecom, but not electricity. Percentages are calculations of average annual infrastructure spending needed over 2008-15.

The methodology used to produce numbers like those in table 2 is a simple macroeconomic model linking per capita income growth to demand for infrastructure services (Fay & Yepes 2003; Yepes 2008). It estimates individual sector-specific demand for roads, railroads, telecommunications, electricity, water, and sanitation using lagged dependent variables and controlling for economic growth and other economic and geographic variables. Physical estimates of infrastructure improvements are then converted to investment expenditures using best practice prices. Annual maintenance expenditures are estimated as a fixed percentage of the stock value. This kind of methodology is fairly widely used (see e.g. OECD 2006). There are limitations to this methodology. First, observed infrastructure usage data

do not reflect the demand for infrastructure but the supply capacity of the public sector under given fiscal conditions and administrative capacity. As a result, the observed infrastructure data represent how much governments have invested in infrastructure out of their revenue streams, which increase as national incomes grow. Second, the estimates do not refer to any socially optimal measure of infrastructure. Third, the model assumes a competitive market for infrastructure and therefore a perfectly elastic supply. Fourth, differences in quality are not considered, and finally, investments are assumed to be used efficiently.

Despite the widespread use of such estimates therefore, it is debatable to what extent they manage to capture either demand (in a positive sense) or "needs" (in a normative sense). Clearly if the goal is to accelerate growth and reach the performance of countries like that Korea or China, this would of course require massive spending—something in the order of 10 percent of GDP annually, over long periods. China itself has been investing between 10 to 12 percent of investment in infrastructure in the past decade.

Price as a Signal of Demand

Practitioners with experience like Michael Klein (2011) therefore consider that estimates based on predicted GDP growth do not amount to much and that what matters most is producing infrastructure at a low and reasonable cost and choosing the right design in a way that improves social welfare. Providing these services in more productive ways reduces costs and helps increase income and welfare further. This means, specifically, first establishing the level and type of demand that is welfare-improving and, second, in order to find out whether a project is worth undertaking, relying on a mechanism that tests whether the benefits of a project or service exceed its costs. For most types of infrastructure, cost-covering prices provide such a test. Relying fully on user fees to fund infrastructure services makes sense for all sectors (with the exception mostly of roads where the cost of tolling may be prohibitive). In some cases the role of prices in calibrating demand may also be weakened when metering is very costly and, therefore, not fully applied. Cost-covering prices still provide the strongest protection against wasteful investments. Relying on prices to reveal demand implies that policymakers instruct potential providers to proceed on the assumption that they will not receive any fiscal transfers or subsidies and that regulation will allow them to set prices at cost-covering levels in the aggregate. Providers, whether publicly or privately- owned, will then estimate demand and calibrate it against costs just as any private investors in a normal market would do. The infrastructure provider will then invest and provide the service. He/she can only make money if customers are actually willing to pay the required price. Thus it is assured that investments are welfare improving. Financing happens as in any other market and is again fundamentally the same for private or public enterprises. Firms seek to obtain bank or capital market financing based on the cash flow expected from cost-covering prices. Risks for creditors are limited by the equity of the provider. Proceeding in this way also means that policymakers themselves need not take a view on "need" or demand. They can delegate this to the service provider. Furthermore fiscal transfers are not

required. All this assumes that policymakers are capable of committing credibly to the announced policy of cost-covering prices.

Where pricing is technically or politically not feasible, social cost benefit analysis provides the best way to assess the merits of an investment. As an example, it is worth considering the approach of the Chilean government using cost-benefit analysis for major road projects. When cost-benefit analysis is used to assess willingness-to-pay of users, governments can then provide fiscal transfers that mimic the role of prices in a normal market. For example, for toll roads governments may pay “shadow tolls” to service providers based on the number of vehicles using a particular service. All this is trivial, were it not for the fact that many projects and aggregate investment levels are chosen without explicit mechanisms to ensure as best as possible that welfare is enhanced and productivity raised. All too often neither cost covering prices are charged nor cost-benefit analysis performed.

Barriers to Cost Covering Prices

Despite the attractive logic of charging cost-covering prices for infrastructure services, in practice such prices are not always achieved. Sectors where pricing tends to be politically relatively easy and hence are still attractive to investors are those that sell to large commercially minded customers, such as ports, airports or freight rail. Mobile telephony when it was introduced benefitted from a feeling that is was a luxury good of sorts and, after that, from rapid cost declines due to technical progress. In these sectors private participation has progressed and helped with expanding access.

The difficulties of covering costs are greatest in the politically-charged retail tariff setting for water and electricity. In these sectors prices remain typically below cost-covering levels and thus complicate any attempt to attract new investment. Foster and Yepes (2006), for example, show that 40 percent of countries achieve no cost recovery on formal water utilities; for lower-income countries this figure is as high as 88 percent. Even in OECD countries, only around half of countries have water tariffs high enough to make a significant contribution to capital costs. More recent evidence however has shown that retail prices may be higher than is often argued. Briceno-Garmendia and Shkaratan (2011) present data on electricity tariff structures in 27 countries for 2004-2008. They find that 80 percent of these countries fully recover operating costs, and 30 percent practice full recovery of capital costs. The probable shift towards more efficient technologies in the future implies that it may not always be optimal to charge full capital recovery costs today. The authors argue that most countries find themselves "caught between cost recovery and affordability".

Still, there is evidence that failing to recover costs may in the end hurt the poorest in society. Subsidies are often poorly targeted for example, and because the very poorest do not have access to services anyway, they do not benefit from the subsidies. Banerjee et al (2008) find that in Africa, the poor on average get benefits from utility subsidies that are only a fourth to a third of what a randomly selected household gets. Marin (2009) argues that expanding access is made more difficult by the fact that utilities do not operate in a sustainable

financial manner. Banerjee et al (2008) show that potential revenue from customers will be inefficient on its own to expand utilities access in Africa however.

One would think that it is difficult to attract private investors (or to privatize existing companies) in sectors like water and electricity where setting household tariffs is politically difficult—but in fact this has not been the case. In the power sector, most private participation – about 83% over the last 20 years – has been confined to generation and eschewed the sensitive distribution segment. This presumably allowed governments to avoid tackling retail pricing head on. In many cases power utilities were squeezed between higher generation prices and continued low retail prices. The rise of retail prices from 60 to 80 per cent of cost over the last decade or so may have allowed government gradually to face up to cost pressures. In the water sector, on the other hand, private participation remains, unsurprisingly, very limited. As in power some 70 percent of private participation deals are in water treatment plants, much of it in China, but not in the sensitive retail part of water systems. Cost pressures there may have been contained for private concessions by auctioning them off on the lowest water price. That de facto gave private bidders the existing assets for free and thus allowed price to stay low until assets have to be replaced.

The case for subsidization in some form is compelling however. Due to geographical and technological factors, the poor often pay a higher price per unit than the rich. Water vendors for example charge prices that are several times that of modern services. The capital cost of provision falls rapidly with population density, which has given Asian countries an advantage over those in Africa. Table 3 demonstrates how the capital cost of infrastructure varies according to density; in particular, it can be seen that the cost of a high quality infrastructure bundle is 15 times higher in deep rural areas compared to crowded cities. Foster and Briceño-Garmendia (2010) estimate that in many rural areas the cost of a high quality infrastructure bundle would be as much as 10 to 20 times the annual household budget.

Table 3. Capital Cost of Infrastructure Provision by Density in Africa, in US$ per capita

Density (people per sq km)	Large cities			Secondary cities	Rural hinterland	Deep rural
	30,000	10,000	1,455	1,247	38	13
Water						
Private tap	104.2	168.7	416.4	448.5	1825.2	3,156.2
Hand pump	8.3	8.3	8.3	8.3	16.7	50.4
Power						
Grid	63.5	88.5	184.3	196.7	487.7	943.1
Solar	92.3	92.3	92.3	92.3	92.3	92.3
Roads						
High quality	31.6	94.7	651.3	759.8	269.1	232.4
Low quality	23.6	70.7	486.3	567.3	224.3	193.6
ICT						
Constant capacity	1.1	3.3	22.8	26.6	39.8	129.7
Actual capacity	1.1	3.3	22.8	26.6	129.7	422.1
Total						
Variable quality	325	480	1,031	1,061	940	836
Constant (high) quality	325	480	1,400	1,557	2,837	4,879

Source: Foster & Briceno-Garmendia (2010)

One solution to this problem is to offer the poor, such as those in remote rural areas, access to alternative forms of infrastructure. As shown in the table above for example, changing the infrastructure mix from high to variable quality reduces the capital cost in deep rural areas by almost 85%. Where subsidies are to be paid, it is crucial that they become better targeted towards the poor, and as a corollary to this, that they help expand access. This may for example involve providing connection subsidies and means-testing subsidies as in the Chilean water system. Other methods include life-line rates that provide a minimum level of service at low rates. This is a form of price discrimination, which could be structured so that wealthier households pay prices in excess of cost to subsidize poorer households.[6] Such "cross-subsidization" has the political benefit that it severs the link between service provision and the government's fiscal budget, which in turn helps protect providers from undue political influence (Klein 2011). Cross-subsidization of this nature relies on some degree of monopoly power however, without which competing providers would be able to lower prices for the richer households. In such a case, a tax scheme on providers could perform a similar role, again keeping the government's overall influence limited.

Even in wealthier societies it can prove politically challenging to implement cost-covering prices, because utilities such as water, sanitation and electricity supply are typically considered to be social goods (Kariuki & Schwartz 2005). Politicians may seek private

[6] An important practical barrier to this is that metering is often not performed at the household level. As a result, groups of poor consumers find themselves in the higher consumption – and thus higher tariff – bracket.

investment as a politically acceptable way of increasing prices, and privatization has in many cases resulted in higher prices (Andrès, Guasch, Haven & Foster 2008). Often however, once a public utility has established heavy subsidization as the norm it can be extremely difficult to implement change. For example, Colombia passed the Public Services Law requiring that utility tariffs be raised to cost covering levels in 1994. It took almost ten years to finally achieve the goal, and still around 80 percent of customers benefit from cross-subsidisation (Foster & Yepes 2006). In 2000 a water concession was abandoned in Cochabamba, Bolivia following violent protests from users directed at sharp tariff increases (Guasch 2004).[7] Evidence suggests that much public resentment to private involvement in infrastructure stems from the fact that the process is often seen as being driven by external agencies (DfID 2007).

Despite the difficulties, enabling infrastructure services to be financially sustainable brings obvious benefits. Not only do cost-covering prices help prevent "white elephant" projects, but they provide the necessary incentives for private investment. As Klein (2011) argues, without adequate cash flow investment is not possible, and no amount of financial engineering or PPP structuring can change this basic fact. Once prices are allowed to cover costs, the financial constraints on infrastructure investment become significantly less binding. Focus can then move to the optimal market structure, which is what we turn to next.

MARKET STRUCTURE OPTIONS

Adopting the correct market structure is the key to successful operation of an infrastructure system. Different sectors and sub-sectors have different economic characteristics that imply that what works best for one will not be optimal for another. Many sub-sectors—such as electricity distribution—display natural monopoly characteristics which imply that allowing unregulated competition is unlikely to be the optimal solution. It is essential however to create a market structure that generates competition at some stage of the process so that providers have the necessary incentives to perform efficiently. This has been shown to be more important than the distinction between public and private ownership. Estache, Perelman and Trujillo (2005) show that firms operating under rate of return regulation have productivity lower than or (at best) equal to public operators. Similarly, if PPPs are structured in such a way that providers bear no risk then all the benefits of private provision are lost (Delmon 2009).[8]

A Digression into Economic Theory

Before discussing market structure options, a detour through microeconomic theory is necessary for a good understanding of the issues. A market failure is a situation under which

[7] The Cochabamba "water war" is so famous that it was the subject of several fiction and non-fiction movies including Even the Rain (Tambien la lluvia) with Gael García Bernal in 2010 and Quantum of Solace, a James Bond movie in 2008.

[8] This section (with the exception of the theory digression) draws on Klein 2011.

the so-called First Welfare Theorem (i.e., that a competitive market equilibrium is Pareto efficient) does not hold. Two assumptions are important for the First Welfare Theorem: market completeness and price taking behavior by all agents (Mas-Colell, Whinston & Green 1995) and several conditions embedded in these assumptions are often violated in infrastructure markets.[9] Chief amongst these are externalities, public goods and lack of available credit—three cases of incomplete markets—and lack of competition and natural monopoly—both violations of the price taking assumption.

Externalities are the most important market failure in infrastructure markets. In theory it is possible to create "externality markets" so that they can be priced up like any other good, but in many cases the costs associated with creating the necessary markets outweigh the associated benefits, meaning that such transactions will not take place (Cornes & Sandler 1996). Public goods are a special case of externalities. In particular, a *pure public good* – one that is both *non-excludable* and *non-rival* – is one in which every individual's chosen quantity of the good combines in an additive way to produce a single good, which forms an argument of every individual's utility (Cornes & Sandler 1996). In general, pure public goods are severely under-supplied in market economies. Individuals have no incentive to provide the good except to satisfy their own utility and, therefore, fail to internalize the impact of their actions on aggregate welfare. However, an appeal to the public good nature of infrastructure is wholly inadequate to justify full public provision or even government intervention in a narrower sense. In the case of *non-rival* but *excludable* goods – often known as *club goods* – there are strong incentives for private provision. Because individuals who value the good can be excluded, and hence scarcity can be created, a producer has an incentive to produce more than satisfies her own utility directly. This is not the case with *pure* public goods and, hence, establishing excludability results in a dramatic change in the level of private provision. Indeed, whether private provision of club goods is higher or lower than the Pareto optimal level is ambiguous in theory. An even more dramatic diversion from the pure public good case occurs when there is *rivalry* but *non-excludability.* Such goods – known as *common pool resources* – tend to be associated with severe *over* provision relative to the Pareto optimal level; as in the famous "tragedy of the commons".

A form of externality not considered in the static formulation of the First Theorem is that of a growth-enhancing externality, the existence of which again renders the competitive outcome sub-optimal. Straub (2008) proposes a generic production function like $Y = A(\theta, I)F(K, L, G(I))$ where I is the stock of infrastructure and all other variables are standard. Infrastructure therefore has two effects on aggregate output: a direct effect captured by $G(I)$ and an indirect effect that works through the productivity parameter $A(\cdot)$. The direct effect may not necessarily be a source of externality, depending on how it is modeled, but the indirect effect is a productivity-enhancing externality that cannot be adequately internalized by the market.

[9] Another assumption is that consumer preferences must be locally non-satiated (a weaker version of the "more is preferred to less" principle) but this is not relevant and will not be considered further.

Externalities are necessary but not sufficient conditions for *coordination failure*.[10] The latter can occur when the *marginal* return to investment increases in the number of investors. This means that externalities must also take the form of complementarities. When the number of investors is low, the marginal returns to investment may be too low to justify investment. As the number of investors increases, marginal returns increase to the point where the investment is justified. This can lead to multiple equilibria, as in Rosenstein-Rodan's (1943) well-known parable of the shoe factory. Infrastructure could feasibly suffer from coordination failure both within and outside the system. Within the system, it is often said that infrastructure exhibits *network effects* (complementary externalities). Outside the system, infrastructure could improve the marginal return to aggregate capital, thereby making investments in the wider economy profitable only once an adequate stock of infrastructure exists. In the production function proposed by Straub above, a necessary condition for this possibility is that $\frac{\partial^2 Y}{\partial K \partial I} > 0$.[11] The existence of externalities provides some motivation for public involvement in infrastructure provision—but neither theory nor practice provide much support. Telecoms, for example, clearly exhibit network effects, yet private investment dwarfs that in many sectors which plausibly do not such as water & sanitation.

A further source of market incompleteness that may have particular relevance to infrastructure is that of incomplete contracting; in particular the hold-up problem.[12] This problem arises when an investment is undertaken for a particular trading relationship, but the investment is not fully contractible ex ante (Che & Sakovics 2008). Ex post, bargaining power shifts strongly in favor of the purchaser who is then able to expropriate all of the returns. The existence of such a problem arises because of an inability to fully contract for each level of investment which would then enable the investor to claim her share of the rewards (Felli & Roberts 2000). Infrastructure provision is a prime candidate for hold-up problems since it typically involves a large capital outlay—most of which is sunk—and a slow accumulation of returns. In general, however, the problem is really one of institutional failure rather than market failure. Ensuring that contracts will be honored is the critical issue, not the existence of the contract itself.

Finally, an obvious instance of market incompleteness in developing countries is that of incomplete capital markets. This can be particularly important for infrastructure investment,

[10] See for example Hoff (2000)

[11] Externalities are necessary for coordination failure but they are not sufficient because the externality must take the form of a complementarity, meaning that they increase the *marginal* return to investment. Even complementarities are not sufficient however for coordination failure. Depending on the parameters, it may still be optimal for all to invest, hence resulting in a unique "high" equilibrium.

[12] On the hold-up problem, see Gersbach and Glazer (1999).

which requires a significant capital outlay and long tenors.[13] Though most developing countries do not possess capital markets that can satisfy this need, both domestic and foreign investors can and do raise capital on international markets. To what extent an underdeveloped capital market itself prevents greater investment therefore is *a priori* unclear. This issue is considered below.

The First Theorem assumes that both consumers and producers act as price takers, from which it follows from optimization that marginal benefit equals marginal cost. Utility services such as water and energy are particularly prone to natural monopoly characteristics because they involve a *fixed* and *immovable* connection between the supplier and consumer.[14] Competition must duplicate the fixed capital network which is extremely costly, whereas the cost of adding an additional customer is minimal. As discussed below, this problem can be overcome if it is possible to generate competition *for* the market. In practice, a key problem is that competition *for* the market is seriously undermined by incidence of renegotiation, which can lead to strategic bidding. The lack of competition *in* the market makes this a serious problem that needs to be addressed. Stimulating even limited competition *in* the market however can lead to the Pareto optimum level of production. This can be true in cases of oligopoly for example, even when the assumption of price taking does not hold. With the appropriate incentives, producers can be made to act *as if* they are price takers. Network effects lead to declining average costs, which suggests a natural monopoly but it is declining average costs at the *system* level, so individual providers wanting to join the system on the face of it should not be prevented from entry. Lijesen and Shestalova (2007) argue however that they do constitute a barrier to entry.

Pareto optimality is a minimal criterion for a socially desirable outcome and is entirely neutral on distributional issues (Mas-Colell, Whinston & Green 1995). The implication is that the most glaring indicators of infrastructure deprivation are not direct evidence of market failure *per se*. For example, the fact that a significant proportion of individuals in Sub-Saharan Africa have no access to improved water or sanitation facilities may or may not be evidence of market failure. Recent evidence shows that many of the world's poorest individuals do not have the necessary incomes to purchase modern services such as piped water and a flush toilet if they are to be priced competitively (Banerjee et al 2008). The market will not provide these services but this is not technically a market failure. Government or NGO provision of such services is a necessary response to distributional concerns, not market failure.

To summarize, a market failure occurs only when the fundamental assumptions discussed above do not hold. If an appropriate rule of law within which contracts can be written and

[13] A further source of market incompleteness is that of imperfect information, including adverse selection and moral hazard, but there is little evidence in the literature that either of these problems play a major role in infrastructure provision.

[14] See for example Kahn (1988) cited in Griffin (2006).

enforced does not exist, or if the government regularly expropriates assets, we are faced with an *institutional* failure, not with a market failure. Likewise, regulatory failures are institutional rather than market failures. To a certain degree, PPPs (public private partnerships) have been a response to institutional failures. As the government exerts direct control over the risk of institutional failure, optimal contracting implies that the government should be made to bear such risk (Irwin, Klein, Perry & Thobani 1999). Hence institutional weakness means that private investors often require some form of risk sharing with government.

Under traditional microeconomic theory therefore, the optimal market structure is to allow head-to-head competition in the market for each and every good. The role of the public sector is therefore limited to enforcing law and order and ensuring that property rights are respected. Many infrastructure sectors however exhibit characteristics such that this rule does not hold; in particular they exhibit externalities and/or a cost structure that inevitably results in a single supplier (i.e. a natural monopoly). [15] In this sense, infrastructure is very different from other economic sectors (say, cement production or wheat milling) where competition is easily established, where public ownership improves neither living standards nor the investment climate and is generally associated with bad and expensive products, overstaffing, sinecures for the elite, and wasted fiscal resources. Moreover infrastructure services are generally provided through networks and exhibit network externalities (i.e., returns to users increase with the number of users). Telecom, roads, rail, and electricity are also networked services so that the impact of new investments on growth, output or firm costs will depend on the overall state and extent of the network. In other words, the marginal and average productivity of investments are likely to differ significantly. The same can be said of water and sanitation networks where the public health value of safe water and sanitation systems are likely to increase the more individuals are served. But one should be careful to specify which aspects of infrastructure—including the ownership or control by the private or public sector of assets, the financing of specific investment, and various forms of concessions or contracting—are private or public. Since most forms of infrastructure require appropriate government regulation to be operated, even private arrangements involve a partnership with the public sector to some degree.

Given these characteristics, it is clear that an unregulated competitive market will not always produce the optimal level of investment or service of an acceptable quality. In theory, depending on the type of infrastructure, four market structure options are possible: a competitive market ("competition in the market"); "competition for the market"; unregulated natural monopoly (with free entry); and regulated natural monopoly (with or without legal protection against entry). Evidence on the performance of different infrastructure service provision systems suggests that real competition is worth its costs—

[15] Thus infrastructure is <u>not</u> a public good in the strict sense because it is fairly easy to establish excludability. If not, it would be pointless to charge cost-covering prices.

whether we are talking about competitive markets or systems that rely on repeated auctions for price-setting.[16]

Competitive Markets

In competitive markets, firms are free to set prices and customers have a choice between competitors from whom they buy services. To make a profit, a firm needs to offer services at a better price than their competitors for a given level of quality—which puts a check on the firm's pricing power. An exit mechanism for failing firms exists – sale, liquidation or some form of restructuring.

There is scope for this kind of competition in infrastructure sectors like telecommunications, natural gas and some forms of transport. The best example is a subsector like cell-phone providers. In natural gas there can be effective competition from competing fuels, for example fuel oil. Klein (2011) gives the examples of the German gas system where prices remained unregulated and entry into the pipeline business was possible. In Hong Kong even residential prices for natural gas were unregulated until recently. In the energy sector, competition is feasible among generators and among electricity traders and sellers in larger electricity systems. In the water sector, competition is the norm for water provided by trucks or vendors selling bottles, for example in cities like Lagos. In transport, various forms of competition are possible. Transport ventures, such as bus or truck companies, may compete. Competition is also possible between airports or ports that are in relatively close vicinity. Freight railway companies may face effective competition from road transport over significant distances.

Competition for the Market

Regular competition between enterprises may not be feasible due to the natural monopoly features of some types of infrastructures. For example, networks have these features. Marginal costs tend to fall with additional connections, thus making profitable entry into segments of the network infeasible as long as the network monopoly is free to charge any prices it likes. Because of these declining costs of the monopoly provider, from a social point of view, a well managed monopoly is cheaper than multiple competing providers, and the duplication of network infrastructure would be inefficient.

There are many historical examples of situations where, initially, enterprises competed against each other and the market structure gradually converged toward monopoly provision. For example, water utilities originally competed in Canadian cities by laying competing pipeline networks to supply firms and households but eventually, only one water utility remained in each area and the others left the market. In other cases, a monopoly provider was not challenged because competitors could not undercut its prices.

[16] Empirical assessments include Andres et al. (2008), Gassner (2008), Kessides (2004), Li and Xu (2004), Newbery (1999), Pollit and Smith (2002), Winston (1993) and Zhang (2008), among others.

In case of natural monopoly, it may be possible to auction off the right to provide a monopoly service for a certain period. When a monopoly franchise can be re-auctioned frequently based on the lowest price, prices can be set via auctions mimicking price competition. Firms that lose at auction exit the particular market. Repeated auctions have been used to award waste management contracts or bus franchises. The assets of these companies—garbage trucks or buses—can then be deployed elsewhere if a company loses its franchise. Auctions can be held at regular intervals (typically one to three years) that effectively render price regulation unnecessary.

When assets are specific to a service area repeated auctions are not a sufficient mechanism to select providers and set prices continuously. It is, of course, possible to award any franchise for a natural monopoly by auction and to use the auction to set the initial price. However, repeated auctions of the same franchise tend to be impractical and no auction format has been found that can solve the price-setting problem repeatedly so as to render price regulation unnecessary. For example, when auctioning off water franchises and the incumbent water provider loses, it would be excessively costly to remove the pipeline of the incumbent and have the winner lay new ones – contrary to the case of basic bus and garbage companies. If the assets have to stay, then the following issue arises. If one holds an auction to determine the price of a service, the bidder needs to know the price of the assets. The assets in the ground have, however, no significant market value outside the franchise area. The value of the assets is thus a function of the price that the provider can charge. But that is yet to be determined at auction. So somehow the asset price needs to be fixed before the auction. That is de facto equivalent to regulating prices directly. Hence infrastructure subsectors with natural monopoly characteristics, where repeated auctions can set prices efficiently without regulation, are rare.

In practice, a key problem with generating effective competition for the market is that contracts are often renegotiated. During the period 1985-2000, for example, around 30 percent of infrastructure concessions in Latin America were renegotiated (Guasch 2004). In the majority of cases, renegotiations were initiated by the private investors for their own advantage: 62 percent of all renegotiations over the period resulted in tariff increases for example. Renegotiations can increase the excess profits of the investors and reduce the cost effectiveness for the government. As outlined by Estache et al (2009), the possibility of renegotiation seriously undermines the benefits of competitive tendering as investors can submit strategically low bids and renegotiate tariffs ex post. This means that unless the government can enforce the sanctity of submitted bids, the scope for creating competition for the market may be lost.

Unregulated Natural Monopolies

With unregulated natural monopolies, firms enter freely. In theory of course, the cost structure of the industry implies that only one firm will survive and will therefore have monopoly power; this is the rationale for regulating such industries (see below). In practice

however, consumers may be willing to pay prices higher than that charged by the monopolist in order to ensure *quality* of service. This element of competition can force the monopolist to improve its quality *and* keep prices low so as to undercut competitors. Even in industries that exhibit natural monopoly characteristics therefore, allowing a competitive market structure can still be a viable option. Indeed, such systems exist in surprisingly many places. They have been documented in 32 countries for electricity and 49 for water. Many more cases are likely to exist, because traditionally they have not been considered in studies of infrastructure. Cambodia provides a telling example. De facto over 600 electricity providers in cities and villages are unregulated monopolists. Where they exist, such small service providers provide service to a significant number of households, often more than 50 percent.

As argued above, such systems can be socially desirable when large regulated firms do not function well. Consider the case of electricity. Typically, when a large utility does not provide good service many firms and households use standby generators to assure power supply. Yet, normally regulations forbid citizens to string a wire from their generator to their neighbor. Thus entry into the "wires business" tends to be forbidden. When it is not, people can purchase larger generators and connect a whole township or village at lower cost than relying on standby generation for each party. The resulting mini-power firms may charge monopoly prices, but people may prefer that to low-quality service from the major utilities. Similarly, small pipeline systems or water vending systems "by the bucket" may spring up when small entrepreneurs are allowed to buy bulk water from the official utility for resale and the utility does not benefit from some form of "exclusivity" or legal protection against entry.

When unregulated free entry is allowed into power or water systems access can expand significantly. This is most clear cut in areas, where official utilities simply do not venture. The most dramatic example may be Somaliland, the northern part of Somalia that enjoys a modicum of peace. Here, for example, private electricity companies provide service, sometimes even laying competing color-coded lines to households. Cambodia provides ample examples also for private small water systems that use small plastic pipes to supply villages or townships. Where willingness to pay is adequate small water treatment plants can also be part of such systems. In water these small systems can actually deliver service at unit costs that are not significantly above the unit costs of large modern systems. Existing studies suggest costs that are about 1.5 times that of modern, well-run utilities (Kariuki and Schwartz 2005). In power, unit costs can easily be double or more say 20 to 40 cents per Kwh, but still well below the opportunity cost of having no access or erratic service. Those costs can often reach 100 cents per Kwh or more.

Regulated Natural Monopolies

Under this option, firms provide monopoly service under prices set by a regulatory body. Prices are reset by regulators periodically, typically every two to five years, to take into

account shifting demand and cost developments. The monopoly may be combined with a legal prohibition of entry or not. In the latter case, pricing decisions will depend on potential entrants' options.

In regulated monopolies firms lose pricing freedom. At least the level of prices is set by some regulatory body. The regulator may also determine full price structures. Alternatively it may leave some flexibility to firms under some form of price cap system, where the regulator may set a weighted average price ceiling for a basket of prices. The regulated firm may then vary the structure of prices so as to maximize profit subject to the overall constraint.

Price regulation is open to a variety of pressures on the price setting process that may not arise in competitive markets. Regulators may be under political pressure to lower prices ex post. This is the problem of the "obsolescent bargain" leading to some level of de facto expropriation of firms. Firms in turn may anticipate such risks and underinvest to begin with. Thus the core issue of the regulated approach to pricing is the establishment of a credible regulatory commitment.

Finally, there is the question whether one should provide legal protection (exclusivity) against entry for a natural monopoly business? This is only necessary when the monopoly provider is not free to choose pricing structures so as to keep potential entrants out. This may be the case, because policymakers require the monopoly provider to cross-subsidize customers in a way that encourages inefficient entry. New entrants may then target the customers that pay for the subsidy and offer a cheaper service thus undermining the cross-subsidy system. Otherwise, there is no real reason to provide legal protection. In particular, the option of free entry even within the franchise area of a utility may help provide services with quality parameters that are more attractive to poorer customers than the standard offering of the main utility. Connections may be cheaper. Service package may provide more basic, but cheaper service. Payments terms may be handled more flexibly. The main utility could, in principle, always undercut new entrants if it had sufficient flexibility with regards to pricing, service standards and labor costs. Incentives to do so may be lacking; hence the value of allowing entry (Kariuki and Schwartz 2005).

ENABLING PRIVATE INVESTMENT

As argued above, enabling competition is crucial in improving quality and expanding access. Attracting private investment is of course a necessary condition for establishing a competitive environment, even if state owned enterprises remain important players. The term "private investment" is actually too broad to capture the wide variety of roles that the private sector plays. In many water and sanitation systems for example, the private sector participates mainly through management contracts, and hence plays little or no role on the financing side. At the other extreme, the government may rely on private capital to fund otherwise purely public projects. This is the case when the government issues an infrastructure bond on international capital markets. This latter case is usually described as a

public project. In between these two polar cases is the entire catalogue of PPP relationships, in which the private sector plays some combination of financing and delivery.

In this section we are concerned with how to attract private investment in infrastructure, which we take to imply at least some private role in the delivery of services. The following section will look in more detail at the financial side, and addresses the issue of whether public capital is inherently cheaper than private capital. It is worth noting here that there are well-documented cases of private provision significantly improving services. Shirley and Menard (2002) study the effects of water sector privatizations in six cities in developing countries. In general, water and sewerage coverage increased, rates of new connections increased, and water losses declined. Although the results reported are favorable in all the cities, the degree of improvement varied substantially across them, reflecting initial conditions and the quality of reform design. In addition, the authors identify a number of regulatory failings that, if corrected, could lead to far superior outcomes. Galiani, Gertler, and Schargrodsky (2005) analyze the variation of outcomes across a sample of municipalities in Argentina and found that child mortality was 8 percent lower in municipalities where water services are provided by a privatized company. Their results control for municipality characteristics and for types of cause of death—that is, they restrict the analysis to deaths caused by infectious and parasitic diseases, the diseases associated with poor water quality. Chile's experience in the electricity sector provides another example. The share of the lowest income decile lacking an electricity connection fell from 29 percent in 1988 to 7 percent in 1998 (World Bank 2004). In most if not all instances, privatization experiences in Latin America have shown that competition is good for consumers, including the poor.

Access to Credit

There is a widely held belief—driven by both the volatility and price of international capital—that, in years to come, domestic capital will be crucial in meeting the infrastructure needs of developing countries (Shendy et al 2011, Irving & Manroth 2009, Harris 2003). Currently however, capital markets in most developing countries are rather shallow and not well-equipped to deal with the long-term financing needs of infrastructure projects. Private credit is more easily available in higher income countries in terms of both availability of domestic credit and total available credit to the private sector. Europe, Central Asia and the Middle East & North Africa have the shallowest domestic credit markets. In Eastern Europe, Russia and Central Asia for example, the banking sector only provides domestic credit amounting to 51 percent of GDP (compared to figures as high as 231 percent of GDP in the USA).

In addition to a shortage of domestic private capital, what is constraining investment in infrastructure is the structure of the banking sector. It takes around 25 years for revenues to pay off debts in a typical PPP project (Engel Fischer Galetovic 2010). Hence, long term financing is essential but it is not available in many developing countries where domestic banks typically only hold short-term deposits and liabilities. In Sub-Saharan Africa, for

instance, the longest available loan tenor is 5 years or less, and many countries have a longest tenor for time deposits of just 1 year. Even where longer loan terms are available, high lending rates mean that it is difficult to find infrastructure projects that yield sufficient returns (Irving and Manroth 2009). Although there is a great variation across developing countries, private interest rates are typically very high compared with comparator OECD countries.[17] For domestic borrowing, this of course means that returns to private providers must also be high. Although this is all consistent with a diminishing returns hypothesis, private investors must be sufficiently confident that projects will yield their full potential. Given the array of specific risks associated with infrastructure projects in developing countries – highlighted below – the high lending rates in many developing countries are likely to deter providers, even where potential returns are high.

Since private capital is both scarce and costly in many developing countries, corporations based in developing countries have increasingly been accessing international capital markets. New capital raised through corporate securities offerings and loans from international bank syndicates grew by 300 percent between 2003 and 2006 to $400 billion. In addition, 422 companies based in developing countries have issued bonds on international markets since 2002, 348 of them for the first time (World Bank 2007).

The fact that not enough capital appears to flow to developing countries given that the marginal productivity should be higher than in developed countries is known as the 'Lucas Paradox' (Lucas 1990). In fact private capital *does* flow to developing countries but the distribution of flows is highly uneven.[18] In 2006 Brazil, China, India, Mexico and Russia accounted for 95 percent of bond issuance, 85 percent of bank borrowing and 95 percent of equity offerings by developing country corporations (World Bank 2007). Although such data is not infrastructure-specific, similar countries also monopolise infrastructure finance. Despite the ongoing financial crisis for example, the value of infrastructure projects with private participation grew by 15 percent across developing countries in 2009 (Fay et al 2011). Excluding Brazil, China, India, Russia and Turkey however the overall value would actually have collapsed by 39 percent.

There is clear evidence that the credit worthiness of the sovereign government has important implications for accessing capital, for both public and private investors. When a government's sovereign rating – as measured by the Institutional Investor ratings – falls below 24, a country typically loses all access to private capital markets (Reinhart Rogoff & Savastano 2003).[19] Das Papaioannou & Trebesch (2009) estimate that, over the period 1980-2004, a sovereign default to a private creditor causes a fall in *private sector* foreign

[17] One may think that these 2009 figures to some extent are skewed by the current banking crisis but pre-crisis data show a similar picture.

[18] Various reasons have been given for the paradox, including differences in fundamentals across countries and capital market imperfections. In a nice paper, Alfaro, Kalemli and Volosovych (2008) show empirically that, during 1970-2000, the leading explanation is poor institutions.

[19] Reinhart and Rogoff (2009) argue that controlling for higher sovereign risk in developing countries solves the 'Lucas Paradox' while Alfaro et al (2008) argue that controlling for institutional quality solves the Paradox.

borrowing of more than 40 percent. Government creditworthiness is particularly important for infrastructure capital, given the large upfront costs and the time span required for revenues to cover debts. Indeed, it has been suggested that one of the factors behind the collapse in Latin American PPI in the early 2000s was the contractual default of Argentinean public infrastructure authorities (World Bank 2004). The fact that the majority of African countries do not have foreign currency debt ratings severely limits their availability of external private infrastructure financing (Sheppard et al 2006). Even where available, it is typically limited to short-term transactions.

Regulatory Commitment

In the past 50 or 60 years, infrastructure provision has gone through cycles of nationalization and privatization. Privatization is often touted as a solution to underperforming and heavily subsidized public industries, and yet political and economic pressures later cause the government to limit private profits and often expropriate private assets. A well-cited example comes from Pakistan when the newly elected government in 1997 announced a 30 percent tariff cut on all private infrastructure providers. Even in countries with strong legal systems and long regulatory traditions pressures to renege on ex ante rules can be strong. In the United States, in the few cases where utility regulators are actually elected by consumer-citizens, pressures to curb prices have tended to undermine service provision (Klein 2011).

Such regulatory risk inevitably leads to under-investment, and this is particularly critical for infrastructure as the sector is characterized by high sunk costs and a slow accumulation of returns. Projects involving shorter-term debt and quicker payback, such as telecoms, are generally favored by investors to those involving long-term debt and longer repayment periods such as toll roads and water & sanitation (Sheppard et al 2006). As argued by Klein (2011), it is therefore critical to implement a price regulation regime that is both credible and sustainable. To render a price regulation regime sustainable one needs to consider various mechanisms to curb ex post opportunism on the part of regulatory authorities. The following paragraphs borrow from Klein (2011). The mechanisms comprise i) the nature of the pricing rules themselves, ii) the legal framework under which rules are made and administered and iii) the organizational arrangements for administering the rules.

(i) Pricing Rules and Commitment

Consider first the pricing rules. The greatest danger of ex post expropriation exists when some form of UK-style price cap is used. The idea behind price cap or incentive regulation was to provide firms with an incentive to perform efficiently. Thus a price would be set. If firms could provide quality service at lower cost than anticipated they could keep the resulting profit. Ex post profits may seem “too high” when the firm was more efficient than expected. Also, prices are independent of how much capacity is utilized. When demand is low regulators may feel pressure to reduce revenues because the price charged is not just based on the cost of capacity actually used but also on that of unutilized spare capacity.

US-style rate of return regulation provides less incentive to perform efficiently, but ex post profit is limited to a maximum rate of return. Based on the "used and useful" doctrine regulators can also vary allowed revenue and provide lower revenue during low demand states and higher ones during high demand states thus matching revenue and utilized capacity more closely. The incentives to renege on the regulatory compact are thus lower under US-style regulation and investors are more likely to invest and expand an infrastructure system, even though during low-demand states they may not obtain sufficient revenue to cover all costs.[20] In practice the differences between price cap and rate of return regulation are in any case not so sharp. A pricing rule that enhances commitment may well be superior, particularly in countries where expanding access and thus new investment is a priority.

(ii) Legal, Contractual and Institutional Framework

Any pricing rule will be laid down in some form of legal document. It may, for example, be written in the law, in a regulatory statute, a license or a contract. Depending on the country, different types of legal arrangements may have greater or lesser commitment value. Where independent regulators are functioning well a statute-based approach may be adequate. In countries where investors seek protection from potentially arbitrary regulators they may prefer contracts[21] that are subject to supervision by courts or even regulation enshrined in the law, which may make it hard to change. The legal form that regulation sensibly takes is thus dependent on the quality of the institutions safeguarding and administering the regulation.

At the same time a trade-off exists between establishing commitment and leaving room to adjust regulations in response to unforeseen circumstances. Managing the trade-off between providing firm commitment and discretion is the key design issue in establishing regulatory institutions. Typically the search is for insulating the regulatory body from undue political interference and influence-peddling by regulated firms, while at the same time providing the regulator with some necessary flexibility in applying rules. Autonomy of the regulator needs to be balanced with accountability. The detailed design parameters are fairly standard and include such issues as whether to locate the regulator in a ministry or at arms-length from the executive branch, who nominates and selects regulators, who pays them and how, how much budgetary autonomy they obtain, the circumstances under which regulators may be dismissed, the processes they have to follow to establish transparency and so on, often with minute details. By way of example, regulators under "sunshine laws" in the US are not allowed to talk to each other one on one. Others have to be present to hear what they are saying so as to prevent "backroom deals".

[20] Other schemes exist that can help build credibility. For example, the German electricity company, RWE, originally escaped nationalization by allowing government to share 50-50 in its profit. This is similar in spirit to the sharing of resource rents sometimes found in mining contracts, for example resource rent taxation.

[21] Some authors, e.g., Gomez-Ibanez (2003) call this "regulation by contract". It is fundamentally not different from other types of regulatory rules but relies to some degree on court-based enforcement.

(iii) Dealing with Problem Enterprises

Policymakers or regulators may fail to honor a bargain—but enterprise managers may do so as well. Firms may bid low in an auction to obtain a regulated franchise and later attempt to renegotiate contracts, notably prices (Guasch 2004). State-owned firms may become virtual states within the state (think of BP, Elf-Total, Gazprom, etc). Firms may also simply perform poorly. They may clearly violate undertakings or they may perform poorly without explicitly breaking commitments. Poor performance may lead to higher prices or lower quality. At the time of a price review regulators may then be under pressure to accommodate poor performance being de facto held hostage by incumbent firms.

To some degree the process of choosing a firm when a franchise is awarded can mitigate such risk. Pre-qualification rules help select financially and technically strong providers. Performance bonds can provide a financial incentive for firms to live up to their agreement. Choosing firms that have an interest in maintaining good reputation (rather than fly-by-night operators who may not be around for long) can help.

Yet, no such mechanism is perfect and even well-selected providers may develop problems after some years. Whoever is in charge, policymakers, regulators or concessionaires need the ability to change providers that end up not performing. Typically, the rules of a franchise, for example, a concession contract, can set out deliverables and standards. Such documents may run into hundreds of pages detailing requirements of service. Alternatively such requirements may be laid down in licenses, laws or other types of regulations. When firms do not meet their obligations, they may be liable to pay fines, make up for substandard service or face termination. For example, French concession contracts and British privatization licenses contain clauses that allow for termination based on defined faults committed by operators.

Still, a regulatory body of infrastructure firms may come to the view that the firm is just not performing well enough even without committing legally sanctionable faults[22]. Hence it can be useful to allow for termination without fault. Again this may be accomplished in various ways, such as in concession contracts that by definition run out after some time or as in British privatization licenses where the secretary of state is given the power to terminate a franchise without fault. Typically, such "concession" periods extend over one or more decades to provide certainty to providers. A big issue tends to be the incentive for franchisee to invest as the end draws near. This depends crucially on compensation rules for the case of termination without fault. [23]

[22] This is just as in the case of an employment relationship, where a supervisor may judge the quality of the work of an employee poor even though no transgression has occurred that is verifiable in dismissal proceedings.

[23] A concession scheme that yields a compensation payment mechanism as a by-product of bidding is the Least-Present-Value-of-Revenue bidding scheme (Engel et al. 2001)

State-owned firms can also be terminated, when there are competing ones to take over. Normally this happens when state-owned firms operate outside their own country. At home it is much harder to displace them. Still governments can change management. Yet, the time horizons and career possibilities of individual managers may provide for less interest in guarding a good reputation than those of firms seeking to operate for a long time in multiple jurisdictions.

Political Commitment

A more subtle risk that investors face is that the government will lose interest in private infrastructure investment and fewer opportunities will become available. Investors who do not believe that there is long-term political commitment are less willing to develop a presence in the market. The government must therefore give clear signals of its long term support for PPI and provide a "well thought through and supported program of opportunities" (World Economic Forum 2010). In the United Kingdom, in 1997, the incoming Labour government commissioned a review that provided a clear statement of the government's support for PPI. By September 2009 this had led to the signing of over 600 projects with a combined capital value of over £55 billion. By contrast, in the United States, the US P3 program provided significantly fewer opportunities than anticipated and as a result numerous international investors downsized or left the market completely. India's five-year plan (2007-2012) outlined clear long-term support for private investment and estimated an overall investment requirement of $492 billion for railways, roads, ports, power and water facilities. India now has the largest PPP program in the world (World Economic Forum 2010).[24]

Alongside political support, there is strong evidence of the need for a clear and transparent tendering and award process (World Economic Forum 2010). In some countries, providers know that they must have the backing of political insiders to stand any chance of winning a project award. In such countries, the number of private providers is dramatically reduced (Sader 2000).[25] The costs of corruption in all its forms is likely to be a significant factor preventing larger flows of PPI: firm-level evidence suggests that underestimating corruption, bureaucratic delays and other non-conventional risks reduces infrastructure FDI returns by around 8-10 percent in emerging markets (Merchant International Group, cited in Sader 2000). Such miscalculations do not last forever, and the inevitable result is that future investment levels will suffer.

Macroeconomic Stability

It is useful to distinguish here between *host* and *home* country stability, where home refers to the location of the investor and host refers to the location of the project. In terms of the

[24] Clearly such evidence is not causal but we have not found causal estimates in the literature. Sader (2000) provides further examples of the benefits of an explicit government commitment to PPI.

[25] Grout 2005 argues that competition in tendering is the most important factor in success of PPP projects, so overall cost to government increases when competition is limited.

host country, the most important economic factors appear to be exchange rate fluctuations and the creditworthiness of the government. The best evidence on the impact of exchange rate fluctuations comes from the Asian crisis of 1997. As shown by Sader (2000), infrastructure FDI flows to developing countries fell in 1998 by around $3 billion—a figure that is actually biased upwards by a wave of telecoms privatizations in Brazil. Excluding Latin America, these flows fell by about half. In addition to a flow effect, exchange rate fluctuations (and in particular the risk of devaluation) also increase the returns demanded by investors and hence user prices (Gray & Irwin 2003). Unfortunately, empirical estimates for the size of such effects are lacking.[26] The creditworthiness of the sovereign government has important implications for accessing private capital, for both public and private providers.

Home country conditions are also clearly important for private capital flows, as the current financial crisis has highlighted. As investors have become more pessimistic, there has been a "flight to quality", with PPI collapsing in developing countries outside Brazil, China, India, Russia and Turkey (Fay et al 2011). Looking beyond purely infrastructure capital, Reinhart and Rogoff (2009) have shown that banking crises in global financial centres produce a "sudden stop" of lending to developing countries, irrespective of host country conditions.

PUBLIC VS. PRIVATE FINANCING FOR INFRASTRUCTURE

The previous section reviews some of the factors that are crucial in attracting private investment. Although the evidence suggests that private investment has often brought significant efficiency gains, it is often held that private *finance* is inherently more expensive than public finance. This issue has generated particular interest since the global financial crisis of 2008-09 as the cost of private capital has soared. At the same time, many governments are borrowing at historically low rates. In the United Kingdom for example, the National Audit Office has recently declared that the Private Finance Initiative no longer represents the best value for money. In developing countries, private infrastructure deals now take longer to close and financing involves lower debt-to-equity ratios, higher transaction costs and shorter debt tenors (Fay, Toman, Benitez and Csordas 2011).

The Cost of Capital and Value for Money

Public authorities aim to finance an infrastructure project at the lowest possible cost. A number of developed country governments use an approach known as value for money analysis—comparing the overall financial cost for public authorities of a PPP contract against that of a (hypothetical) public sector comparator (PSC). The PSC is a risk-adjusted calculation of what the cost of the project would have been, in net present value (NPV) terms, had it been delivered through 'traditional' public-sector procurement. Creating an accurate and unbiased PSC is difficult, and a number of authors question the effectiveness of the approach (see e.g. Grimsey & Lewis 2005, Grout 2005, Leigland & Shugart 2005). As an

[26] For a discussion of the influence of exchange rate fluctuations on prices, see Gray & Irwin (2003), Harris (2003) and Sheppard et al (2006).

example, consider the figures in table 4. Cuthbert and Cuthbert (2008), from which they are taken, use data on the value of private capital invested in a Scottish PPP contract, and the value and timing of payments from the government to the investors. To assess whether the private investment represents value for money, they present calculations under different assumptions for the discount rate.[27]

The most dramatic results are obtained with a discount rate of 5 percent—which is arguably the most appropriate: 5 percent is the rate at which the public sector could have borrowed at the time from the UK Loan Fund. Hence £416.2 million is the amount the public sector could have borrowed in the first period at the same overall cost as the total payments made to private investors. The public sector could therefore have borrowed twice as much capital for the price it ultimately paid the private investors (column 5). On these grounds, it appears that using public as opposed to private capital could have delivered two projects for the price of one.

Table 4. Financial projections for a 30-Year Scottish PPP project signed in 1998

	Capital raised (£m)	Total payment (£m)	NPV of total payment with 5% discount (£m)	NPV/Cap with 5% discount factor	NPV of total payment with 8% discount (£m)	NPV/Cap with 8% discount factor
Total value	189.2	760.2	416.2	2.04	310.53	1.45
Tax		167.2	69.8		43.4	
Senior debt	161.3	369.6	229.6	1.3	179.5	1.0
Sub debt + equity	19.8	228.6	102.6	4.8	68.4	3.0

Source: Cuthbert & Cuthbert (2008)

Such an analysis is not possible without project-specific information on the volume of capital raised and the total payments provided by the public authority to private investors. Although it appears that private investment is twice as costly as public investment, no account is taken of the value of risks that are transferred to private parties, or the relative efficiency of public and privately managed projects. Such risk transfer is often the main motivation for private investment (Delmon 2009, Yescombe 2007) and so should form an integral part of any value for money analysis. The complication is that private investors have priced the value of the risk into their required returns, but the public borrowing rate is unadjusted for project risk. To accurately compare the two, the value of risk that would have been borne by private investors must be *added* to the cost of public investment. There may be additional risks for the public sector resulting from private investment, such as the increased risk of contract renegotiation. These risks should be *subtracted* from the price of public investment.

A proper accounting of risk transfer is the most complicated and controversial aspect of value for money analysis (Grimsey & Lewis 2005; Grout 2005). A second aspect that must also be considered is the relative efficiency with which public and private capital is used. In

[27] The main disagreement in the literature on value-for-money relates to the choice of discount rate. The approach of Cuthbert and Cuthbert (2008) avoids the controversy by presenting calculations under different assumptions for the discount rate. It does not claim that any choice is 'optimal'.

the example above, the public sector could only have delivered two projects for the price of one had public capital been used equally efficiently as private capital. To accurately compare the overall costs of public and private investment therefore, estimates are required for the value of private investment, the returns made by investors (captured above by total payments), the value of risk transfer and the relative efficiency of each type of investment.

The internal rate of return (IRR) captures the annual return made by investors on the capital they have committed to a project. From the perspective of value for money analysis, such returns ultimately come from the government, either in the form of direct payments or foregone revenues (Yescombe 2007). The relationship between the IRR and the total payments made by the government to private investors is captured by the equation:

*Total payment = private capital raised + IRR * average notional debt * number of years*

- IRR = the (private) internal rate of return
- average notional debt = the average level of private debt outstanding
- number of years = the contracted number of years over which private investors will receive returns.

This formula captures the fact that from the perspective of the government, the IRR acts like an interest rate on a loan. If the IRR is higher than the rate at which the government could borrow elsewhere, justification for private investment must come from either risk transfer or efficiency gains. Currently, available data on IRRs is limited, particularly for developing countries. Table 5 shows that the IRR varies depending on the stage of project development and the degree of market risk. If private investors are to be involved with the construction and development phase of a project, required returns are likely to be in the range of 11 – 16 percent. Such estimates may well be conservative, particularly for developing countries. According to estimates produced by the agency CEPRES, the mean IRR on infrastructure projects over 1988-2007 was as high as 34 percent and, in Asia, was a staggering 67 percent. The CEPRES results are questionable however because the sample is skewed towards riskier private equity-type investments (Weber and Alfen 2009).

Table 5. Gross Internal Rate of Return of unlisted infrastructure assets, 1988-2007

Category	Description	Nominal gross IRR
1: Mature PPP	Assets under government PPP programs with minimal market (demand) risk. Construction is already complete.	6 – 10 %
2: Regulated utilities	Monopolies regulated by the government with minimal demand risk.	7 – 11 %
3: Early phase PPP	As per category 1 but Greenfield, i.e. not yet constructed.	9 – 13 %
4: Mature general infrastructure	Monopoly-type investment but subject to some market risk.	10 – 14 %
5: Early phase general infrastructure	As per category 1, but with development and construction risk.	11 – 16 %
6: Other infrastructure non-regulated	Assets with infrastructure characteristics, with demand risk and no price regulation.	12 % plus

Source: Weber & Alfen (2009)

Another measure is the weighted average cost of capital (WACC)—also known as a hurdle rate to capture the fact that returns must be above this level to attract investors. It can be used as an approximation of the cost of private capital since empirical data on IRRs is limited. The WACC is the rate of return a company can otherwise earn at the same level of risk as the investment it is considering, i.e., the opportunity cost of capital (Sirtaine et al 2004). It represents the minimum price that public authorities can expect to pay to access private capital. If there is strong competition in tendering, the WACC should closely approximate the IRR. Estache and Pinglo (2005) present WACC estimates using a sample of 120 companies spanning 31 developing countries over the period 1998-2002 in electricity, water & sanitation, railways and ports. They estimate an infrastructure WACC of around 15 percent in low-income countries, 11 percent in lower-middle income countries and 10 percent in upper-middle income countries. The highest WACCs, almost 15 percent, are in South Asia and Sub-Saharan Africa. Such results are not very encouraging in terms of financing infrastructure in the poorest regions: “These results suggest that the poorer the country, the higher the risk, and hence the higher the cost of capital which, in turn, implies that the poorer the country, the higher the average tariff all other things, including technology, being equal” (Estache and Pinglo 2005, p.60). In a similar paper, Sirtaine et al (2004) use a sample of 34 concessions across Latin America in 2004 and in 6 infrastructure sectors: roads, ports, water, telecoms, energy distribution and energy generation. Across countries, the average infrastructure WACC ranges from 3 percent in Chile to 14 percent in Argentina and Venezuela. As an example of how the WACC varies across both sectors and countries, table 6 presents the WACC in both the USA and Argentina for each infrastructure sector. For Argentina, investors typically demand minimum returns of around 14 percent to invest in infrastructure projects, compared to around 3 percent in the USA.

Table 6. Estimated Weighted Average Cost of Capital, by sector, USA and Argentina, 2004

	USA	Argentina
Roads	3%	14%
Ports	3%	13%
Water	2%	13%
Telecom	5%	15%
Energy distribution	3%	14%
Energy generation	2%	13%

Source: Sirtaine et al (2004)

The IRR and WACC represent the cost of private investment from the government's perspective. If it is higher than other sources of finance, then risk transfer and/or efficiency gains are necessary to justify private investment. In practice, the terms at which governments can borrow depend heavily on the lender, and this is particularly true in developing countries as a result of the numerous multilateral organisations offering concessional financing.

Table 7 provides details on the concessional terms offered by a number of development banks and bilateral donors on their loans to developing countries. Two World Bank affiliates lend to developing countries: the International Development Agency (IDA) and the International Bank for Reconstruction and Development (IBRD). The terms of IDA loans (available only to countries that have a 2010 GNI per capita below $1,175) are highly concessional, whereas IBRD loans are based on the 6 month LIBOR rate, plus a risk premium and other nominal charges. Currently, the longest maturity fixed spread IBRD loan is charged at the LIBOR rate plus approximately 1 percentage point. At no time over the past twenty years have interest rates on external debt been so low in developing countries. The average interest rate paid on external debt varies greatly by region. The lowest lending rate can be found in Sub-Saharan Africa, reflecting the fact that a significant proportion of its debt is in the form of concessional lending. Although the rates are above those paid by the majority of developed county governments – at least before the current crisis – they compare favorably with the cost of private infrastructure capital mentioned above.

Table 7. Concessionality of Loans by Development Banks and Selected Creditors [1/]

Creditor	Grace Period	Maturity	Interest rates	Service Charges	Commitment Charge [4/]	Repay-ments per year	Repayments Profile	Currency	Current IMF Method [2/]	CIRR 2003 [3/]
IDA40	10	40	0.75%	0%	0.50%	2	IDA40 [6/]	SDR & USD	82.00%	63.22%
IDA35	10	35	0.75%	0%	0.50%	2	IDA35 [7/]	SDR & USD	77.83%	58.09%
IaDB [5/]	10	40	1% & 2% [8/]	0%	0%	2	EQUIP	Multiple	76.33%	57.01%
IMF	5.5	10	0.50%	0%	0%	2	EQUIP	SDR	38.21%	26.69%
African Dev Bank	10	50	0.00%	0.75%	0.50%	2	Specific [12/]	Multiple	84.42%	67.45%
Nordic Dev Fund	10	40	0.00%	0.75%	0.50%	2	EQUIP	SDR	72.00%	49.59%
IFADI	10	50	1.0%	0%	0%	2	EQUIP	SDR	72.64%	49.95%
OPEC	5	20	0.50%	0%	0%	2	EQUIP	USD	56.56%	35.76%
JBIC	10	40	0.75%	0%	0%	2	EQUIP	Yen	49.40%	33.86%
EU	10	40	0.75% [9/]	0%	0%	2	Specific	EUR	73.01%	54.57%
BADEA	10	30	1% [10/]	0%	0%	2	EQUIP	USD	67.48%	42.87%
EIB	10	50	1% [10/]	0%	0%	2	Specific	EUR	73.62%	55.16%
Asian Dev Bank	8	32	1% & 1.5%	0%	0%	2	EQUIP	USD	71.89%	51.80%
Islamic Dev Bank	10	30	0.00%	0% [11/]	0%	2	EQUIP	SDR	74.48%	53.99%

Source: World Bank (Estimates based on publicly available information for each institution).

1. For some creditors, lending terms vary depending on the borrower country and/or the project financed. For simplicity, those conditions which represented the "softest" loan terms were used to calculate the grant element.
2. Refers to concessionality calculations for debt ceilings in Fund-supported programs, which uses 10-year averages of CIRRs as discount rates, plus a spread subject to the maturity period. For loans with maturity of less than 15 years, the CIRR 6-month
3. Current CIRR six-month average.
4. Levied on undisbursed amounts. For the purpose of this exercise, it was assumed that the loan is disbursed in one observation.
5. IaDB lends in multiple currencies, in this case the discount rate used was the USD CIRR.
6. 20 percent of the loan is repaid during the first 10 years after grace period. The rest is paid afterwards.
7. Principal repayable at 2.5 percent per annum during the first 10 years after the grace period and 5 percent per annum afterwards.
8. 1 percent during the grace period, 2 percent afterwards.
9. Current rate ranges from 0.75 percent up to 4 percent.
10. Current rate ranges from 1 percent up to 4 percent.
11. Current rate ranges from 0 percent up to 2.5 percent.
12. 10 percent of the loan is repaid in the 10 years following the grace period and the remaining 90% over 30 years.

see http://treasury.worldbank.org/bdm/pdf/Pricing_Basics.pdf

Controversies

It appears therefore that governments have significantly cheaper access to capital than private investors. The case is often made however that the apparent cheapness of public capital reflects the fact that taxpayers are implicitly providing insurance for public investments, whereas private investors explicitly price risk into their cost of capital. On these grounds, there is no inherent cost advantage of public as opposed to private capital; if taxpayers were properly remunerated for the insurance they provide then the apparent cheapness of public borrowing would disappear (Klein 1996). This argument is now well established and is explicitly used to justify the cost of PPPs in the UK (HM Treasury 2003). If this is correct, the choice between public and private investment should rest on the efficiency with which each is used.

There are a number of caveats to this argument. It only applies to funds raised on competitive capital markets whereas a number of developing countries receive highly concessional financing, as shown in table 7. In this case, the government of course possesses a clear cost advantage over private investors and private financing will remain more costly (holding efficiency constant) even accounting for risk transfer. Even without concessional financing, the argument is true only if the IRR and WACC are equal; if the IRR is greater than the WACC then investors are making excess profits – and so the public sector is paying a higher price for capital than that implied by risk transfer (Hellowell & Pollock 2009). Only with healthy competition can excess profits be assumed to be small, and even in this case they are likely to be positive. The IRR was estimated to be around 2.4 percentage points higher than the WACC between 1995 and 2001 in a sample of 64 UK PPPs (Price Waterhouse Coopers 2002).[28]

A further doubt about the value of private funds, from a risk transfer perspective, is whether such transfer is *real* or simply *apparent*: the government may be paying private investors a risk premium but implicitly underwriting such risk anyway. In this case the government pays private investors for risks they do not really bear. This is the case with implicit liabilities, where the government picks up the tab when projects fail, even though they have paid private investors to bear this risk.[29] In Mexico, for example, the government bailed out the concession toll road program in 1997 at a total cost of around 1 – 1.7 percent of GDP (Estache et al 2009).

Other arguments used in favor of private finance are as follows.

Distortionary Taxation. The most common argument is that it reduces the need for distortionary taxation. Foster and Briceño-Garmendia (2010, p.82) argue that each dollar

[28] The evidence from Estache & Pinglo and Sirtaine et al. actually showed that the IRR was typically smaller than the WACC. But presumably this is the exception rather than the rule and means that private investors underestimated the risks – government probably benefitted from private investment in this case.

[29] These kind of instances are different from contingent liabilities, which the government explicitly provides to private investors in an attempt to attract investment and reduce the cost of capital.

raised and spent by a Sub-Saharan African government has a social value premium (or marginal cost of public funds) of almost 20 percent. This premium captures the changes in consumption patterns, administrative costs and labour supply induced by taxation. Although the government can *in theory* access cheap debt, the reality is that most infrastructure finance is raised through taxation.

In the context of infrastructure, however, this argument is not convincing. Firstly, there can be significant administrative costs associated with private as well as public financing. Delmon (2009) for example argues that administrative costs associated with contracting and regulation of PPP projects add on average 2.6 percent to the cost of capital in the UK; similar estimates have been made for Australia. In fact, given that the administrative costs of PPPs are so high, it may be the case that PPP projects must be sufficiently large to be justified (Chan et al 2009). More importantly, if a service does not achieve cost recovery then revenues will ultimately be provided via taxation whether the initial financing was public or private. The distortionary taxation argument only applies if private investors are better at collecting revenues than public investors. As seen above, even privately financed services are often heavily subsidised (or more generally rely on government purchases) and so the "marginal cost of public funds" argument also applies to privately financed infrastructure projects (Reiss 2008).

Endogenous Risks*.* Engel, Fischer and Galetovic (2010) argue that it is wrong to consider the potential efficiency gains of private investment as being distinct from the cost of capital. Part of the explanation for the higher cost of capital is that there are endogenous risks that the firm must bear under a PPP, but such risks provide the necessary incentives for the firm to reduce costs. By having the same firm in charge of both construction and operation and maintenance (O&M), efficiency gains are realized as decisions are taken that optimize efficiency over the life of the project. Under public provision, by contrast, different firms are contracted for the different stages of the project and hence such efficiencies are not realized.

Credit Constraints. (This paragraph and the next borrow from Klein 2011) Some governments decide to privatize infrastructure ventures so as to obtain added resources. However, when one considers the balance sheet of a government, all this does is to convert an illiquid asset (the infrastructure company) into a liquid one. Net wealth remains unchanged, if the sale is at market prices. To obtain liquidity governments could also have borrowed an equivalent amount. If they sell an infrastructure company, they lose its future revenues. If they borrow, they need to pay debt service in the future. When credit constraints play no role, these transactions are equivalent. Easterly and Serven (2003b) refer to this as "illusory adjustment".

There may, however, be a special case for private infrastructure on financial grounds when governments are credit-constrained. Some governments may not be creditworthy, even if they receive user fees from infrastructure customers. Financial markets may not trust that

the state will apply the user fees to service financial obligations in the future and fear the government may be tempted to divert user fee income to other uses. This may also be the case when the infrastructure venture is run by a separate state-owned enterprise and it is feared that the government may withhold or tax the revenues in some fashion. In this case, privatization can act like a form of collateralization. The act of privatization establishes an arms-length vehicle (a firm) that receives the user fees for the infrastructure service it provides. The creation of private property rights may in many jurisdictions provide stronger protection for investors than promises by the state or its enterprise. This form of collateralization or introduction of "hard budget constraints" may make finance flow again to infrastructure ventures and help expand systems. The strongest evidence on the superiority of private solutions over public ones is consistent with this (Galal 1995). For example, the infrastructure privatization episodes analyzed in the heydays of privatization in the 1990s show that the main benefit was a relaxation of constraints on investment. This then led to system expansion and greater overall benefits. At the same time the government may obtain liquidity in this way that may be very valuable when it is credit-constrained.

CONCLUSIONS

To summarize, there are three ways to finance infrastructure projects: public financing (on- or off-budget), private financing, and public-private partnerships (PPPs). Each method has associated costs and benefits, and no single approach dominates the others in all situations. Whilst direct public provision is the most traditional form of financing, a number of countries do not have the fiscal space required to fund necessary infrastructure improvements. This is certainly the case for low income countries but also for many Latin American, Eastern European and Central Asian countries whose fiscal positions have deteriorated markedly as a result of the 2008 and current global financial crises. For Africa, it is estimated that—even under an optimistic scenario in which significant efficiency gains would be made—Africa would still have an infrastructure funding gap of around $31 billion per year (Foster and Briceño-Garmendia 2010). Private participation in infrastructure has brought additional financing and, in many cases, contributed to improvements in productivity. However, it depends on the potential for cost recovery and the quality of the regulatory framework. Overoptimistic expectations of private sector participation in the financing of infrastructure have led to major calls for "fiscal space" in public accounts (i.e., less stringent fiscal rules) to finance the necessary investments. There is increasing evidence that standard fiscal rules adopted to ensure debt sustainability have resulted in a disproportionate reduction in infrastructure spending and that the current political and ideological climate encourages policymakers to postpone large and costly infrastructure investments.

The public sector remains the dominant source of financing for water, energy and transport in most African countries. Such investments are largely financed through tax revenues and sometimes user fees. Operation and maintenance costs often rely on user fees. For poor countries which cannot access capital markets, overseas development assistance (ODA) for

public infrastructure has been substantial. Following the 2008 financial crisis, there was a short-lived increase in ODA (Fay et al 2010), infrastructure being seen by many donors as a promising stimulus measure. Such levels are unlikely to be sustained however.

Governments still play a large role directly providing infrastructure in most developing countries, in addition to their role as regulator of the private (or privatized) sector. Studies have highlighted the efficiency gains from privatization, with telecommunications often noted as an important example.

The central question is whether government ownership and operation of infrastructure and public utilities improves living standards and enterprise productivity. On the service delivery side, low-income consumers facing public monopolies have little choice or voice in seeking improvements in access or quality. When prices are kept low by government subsidies before privatization, the benefits often accrue to middle-income and rich people rather than poor people. Similarly, evidence shows that traditional cross-subsidies associated with monopoly state-owned firms (where some consumers are charged a price much further below marginal cost than others) often benefit the better off more than poor people (see e.g., Brook and Irwin 2003; Estache, Gomez-Lobo, and Leipziger 2001). In addition, fiscal constraints on subsidized monopolies often lead them to invest too little in expanding or maintaining services—so marginal, usually poorer, neighborhoods have little or no physical access to a variety of public services.

It is reasonable to argue that in many cases it is cheaper for the government to raise infrastructure funds itself rather than rely on private finance. This is true when the government has greater access to concessional finance, and when private investors make excess profits. This last point highlights that what is important from a value-for-money perspective is not the cost of private capital per se (captured by the WACC) but the price the government pays for it (captured by the IRR).

If the cost of private capital *is* greater than public capital, properly adjusted for risk, the case for seeking private investment *for a given project* rests on efficiency gains. Private investment may be a way of ensuring that the best projects are selected and that access is expanded. A large volume of work has compared the efficiency of private and public infrastructure providers, with the general consensus being that private investment has typically brought efficiency gains. Evidence from Latin American reforms for example suggest significant efficiency gains on average, after the introduction of concession contracts, ranging from 1 to 9 percent per year (Guasch 2004). Some of the sectoral evidence is reviewed in Estache, Perelman and Trujillo (2005). A number of studies on energy find that private investment has resulted in greater efficiency—in the order of 5 to 7 percent per year in Latin America for example. The number of studies analysing efficiency in the water and sanitation sector is too limited to draw any conclusions. In transport, the evidence suggests that private operators have tended to perform more efficiently. In telecommunications, the

general consensus is that there have been significant improvements resulting from private investment.

This paper argues that a more important determinant of performance than private ownership is the degree of competition and the incentives created by the market structure. Estache, Perelman and Trujillo (2005, p. 21) also state that "across sectors, the more relevant variables include the degree of competition, the design of regulation, the quality of institutions and the degree of corruption" (p.21). Generally the evidence suggests that private participation tends to result in efficiency gains but it is not a sufficient condition, depending on market and institutional conditions. This paper has focused on market determinants but institutional determinants are also important. Estache and Kouassi (2002) for example find that quality of governance significantly increased efficiency in African water and sanitation services, whilst the level of corruption significantly decreased efficiency.

Value for money analysis is a means of comparing the cost of various approaches to delivering a given project though it is not primarily concerned with other important issues such as the selection of projects and the expansion of access. This paper argues that raising prices to cost covering levels is a useful way to ensure that the best investments are undertaken. It also argues that they can help in expanding access as utilities become more financially sustainable and therefore have more capital to invest.

Private participation itself can help in expanding access if there is a potential for a return on new investments. Even with cost covering prices, private providers may exert more effort in opening up new markets. Physical access to water, telephone, sanitation, and electricity services has indeed improved after privatization in a number of countries, simply through renewed investment in physical networks by the new private owners. Economic access—through affordable prices for poor people—is a more complicated issue because it involves the more difficult institutional and design issues associated with regulating prices or designing directed subsidies for poor people. In any case, the scope for improved access will depend on the success in achieving efficiency gains—some increased surplus—that can be passed on to poor people. Thus, in principle, with appropriate regulatory institutions, privatization and concession contracts can deliver both improved access to goods and services for poor people and better financial performance for the company.

Still, many practical difficulties can arise with privatization. First, with limited government finances, direct subsidies for low-cost services for poor people may be difficult to finance. So there is a risk in terms of whether government will be able to sustain transparent subsidies after privatization. These subsidies will compete with other budget demands, while the indirect subsidy of underpricing—and the accompanying losses in government owned utilities prior to privatization—often could be hidden for years. In addition, there is a risk that the transfer of assets at the time of privatization could empower rich people rather than poor. Poorly designed auctions can lead to one-off transfers of wealth from the public sector (taxpayers) to the new investors (domestic elite or foreign investors). If privatized firms are

purchased by foreigners, foreign ownership can provoke a political backlash. Infrastructure services often involve some degree of necessity, and people may feel particularly vulnerable to the whims of a private foreign owner. When their government is the owner, they may feel that they have some leverage, even if low prices charged by a state-owned firm come with very low quality. Governments sometimes exacerbate consumers' frustration with private providers, as when they postpone needed price increases until after privatization—so that private firms, often foreign, get the blame.

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